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EXPERIMENTS AND OBSERVATIONS

ON

DIGESTION:

AN INAUGURAL ESSAY,

FOR THE DEGREE OF

DOCTOR OF MEDICINE.

SUBMITTED TO THE EXAMINATION OF THE REV. JOHN ANDREWS, D. D. PROVOST (PRO TEMPORE) THE TRUSTEES AND MEDICAL PROFESSORS OF THE UNIVERSITY OF PENNSYLVANIA, ON THE EIGHTH DAY OF JUNE, 1803.

BY OLIVER H. SPENCER, ✓

OF NEW-ORLEANS, HONORARY MEMBER OF THE PHILADELPHIA MEDICAL AND CHYMICAL SOCIETIES.

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1803.

TO DR. RICHARD ALLISON,

OF THE STATE OF OHIO,

THIS ESSAY,

AS A

TESTIMONY OF THE MOST LIVELY FRIENDSHIP,

IS INSCRIBED,

BY

AN AFFECTIONATE AND GRATEFUL PUPIL,

THE AUTHOR.

TO BENJAMIN SMITH BARTON, M.D.

PROFESSOR OF MATERIA MEDICA, NATURAL

HISTORY AND BOTANY,

IN THE UNIVERSITY OF PENNSYLVANIA,

THIS ESSAY

IS ALSO RESPECTFULLY INSCRIBED,

AS

A TRIBUTE OF RESPECT,

AND

THE MOST LIVELY ESTEEM,

BY HIS FRIEND AND HUMBLE SERVANT,

THE AUTHOR.

EXPERIMENTS AND OBSERVATIONS

ON

DIGESTION.

PREVIOUS to commencing the subject of our essay, it will be proper to take a short anatomical view of the stomach. The other viscera concerned in chyli-fication, by means of the different fluids which they secrete, we think it unnecessary to notice; because in no part of the work shall we examine the changes which the chyle undergoes, after leaving the stomach and mixing with the fluids secreted by these viscera.

The human stomach is oblong, large, and membranous; of different dimensions in different persons, and capable of considerable contraction as well as distention, without much inconvenience: the former state is observed in the savage of our country, who is obliged, frequently, to subsist for months on a spare diet, during which time the stomach is contracted by its muscular fibres, and he returns from his excursions with a considerable depression in the epigastrium, as

well as the whole abdomen: civil society presents us with daily proofs of the latter state, from indulging in the pleasures of the table.

It is situated partly in the epigastrium, and partly in the left hypochondrium, immediately under the diaphragm, and contiguous to the heart, liver, spleen, and pancreas; and when distended with food, lies in an oblique direction, inclining anteriorly downwards and forwards.

The stomach is formed of four tuniæ, or coats, connected strongly to each other, by condensed cellular membrane. The first, or outer coat, is simply membranous, and is common to the intestines as well as to the stomach; being a continuation of the peritoneum, which, after lining the whole cavity of the abdomen, is reflected and forms a covering to all its viscera; in some instances, indeed, but partial, as is the case with the kidneys, which lie without the peritoneum. Immediately under the first lies the second, or muscular coat, composed of fibres in a circular and longitudinal direction, upon the contraction and relaxation of which depends the peristaltic motion of the stomach.

The third may properly be called cellular, being made up, almost entirely, of condensed cellular membrane, and capillary vessels, supported by fine ligamentary filaments. Lastly, the inner coat, termed by the ancients fungosa, is exceedingly delicate, and forms with the cellular coat, to which it adheres, a number

of rugæ upon the inner surface of the stomach, particularly about the pylorus, which serve to counteract its peristaltic motion, by preventing the food from being thrown too hastily into the duodenum.

The nerves of the stomach arise, chiefly, from the par vagum, or eighth pair; and from the intercostalis, or great sympathetic nerve, by means of the stomachic nerve, the ganglions of the plexus hepaticus, and plexus splenicus.

Its arteries are derived, principally, from the cœliac; and as no glands are to be met with in the substance of the stomach, agreeable to Morgagni, Haller, and Sabbatier, it is probable that the gastric juice is poured out by the minute branches of these arteries, which are interspersed throughout the coats of this organ.

The stomach is a viscus of primary importance in the animal economy. To a proper state of its secretion (depending, we suppose, upon a certain tone, and healthy action of its vessels) are we indebted for health, mental enjoyment, and long life. Few men, observes professor Rush in his manuscript lectures, attain to old age, who have been subject, in their youth, to dyspeptic complaints. We cannot, therefore, be surpris'd, when we find it so abundantly supplied with blood-vessels and nerves.

Preparatory to the food being received into the stomach, it is necessary, in most persons, that it should

be minutely divided by mastication, and formed, by mixture with the saliva, into a soft mass; not only to render it easy of deglutition, but to favour, likewise, its more speedy solution in the stomach. To the labouring part of mankind, particularly those who exercise much in the open air, we find that the minute division of the food is by no means so necessary as for sedentary people. The former, we observe, often swallow food of the most difficult solution, almost entire, without experiencing, afterwards, any inconvenience. Exercise gives tone to the system, and by increasing the circulation, a large quantity of gastric fluid is secreted; and food, being well masticated, would, in such a stomach, be dissolved and formed into chyle in greater abundance than is required for the nutrition of the system, if the appetite of hunger was satisfied as often as the stomach became empty.

Happily and wisely for mankind, the gratification of the appetite of hunger and thirst is attended with pleasure, sufficient, in most instances, independent of the love of life, to compensate for the trouble of obtaining the means. The stimulus of the gastric juice upon the sensible coats of the stomach, and the weight of the liver, unsustained and pulling downwards the diaphragm, to which it is attached by means of the middle ligament, causes that uneasy sensation we call hunger, the principal seat of which is generally supposed to be at the cardia. But for this, mankind would not have, perhaps, a sufficient incitement to rouse them from their natural indolence.

By the term Digestion we mean the process which the aliment undergoes in the stomach. It should extend farther, and embrace in its signification, not only this change, but the alteration which farther takes place before the chyle is finally emptied into the subclavian vessels. Want of time, however, will prevent us from going thus far.

Much controversy has prevailed in every age, respecting the manner in which digestion is begun and carried on in the stomach; and, until the talents and attention of Reaumur, M'Bride, Stephens, Spallanzani, and Hunter had been exerted, the subject was involved in obscurity; and for want of a just physiology, the diseases of this organ were frequently very improperly treated. The limits of my essay will not permit me to examine the variety and contradictory opinions which prevailed among the ancients upon this subject. Some of them, for their singularity, are worthy the attention of the curious, but, as relating either to medicine or natural history, are of but little importance in their application.

Trituration, one of the causes, according to ancient opinion, and perhaps the most probable of them, was revived as late as the beginning of the last century; and from the general reception which it met with at that time, it has been common for the physiologists of the present day, when writing upon the subject, to notice the doctrine.

In accounting for this process, fermentation and putrefaction have likewise had their advocates; but the latter having less plausibility, and being disagreeable in its contemplation, has been less generally embraced than the former, particularly since the writings of the celebrated Dr. Cullen have been published. We shall proceed to examine these several doctrines in rotation; and after introducing some experiments performed, not with a view to establish any favourite theory (for I had none when I began them) and quoting a variety of others, ingeniously made by celebrated men in the literary world, endeavour to draw fair conclusions from established facts, unbiassed by prejudice.

The supporters of the doctrine of mechanical force, or trituration, insist on it, as a proof of their theory, that birds digest their food by this means. We cannot conceive how this can be alleged in favour of the opinion; for there is certainly but little analogy between the stomach of man, and the muscular strong stomach of these animals. No doubt the minute division of their food, which is performed in the stomach, assists its solution, in the same way that any substance is rendered more readily soluble in a menstruum by division, inasmuch as a greater surface is exposed to be acted upon by the fluid.

Reaumur took a buzzard, because that bird has a membranous stomach, incapable of any great degree of tritulative power. To preclude, however, the possibility of any, he employed perforated tin tubes, that

would admit the gastric fluid to come in contact with the beef which he employed in the experiment. This was forcibly thrust into the bird's stomach, and remained there twenty-four hours. Upon examination, the beef was found reduced to three-fourths of its original quantity: what remained had the appearance of threads, extremely fine, but was neither putrid, acid, nor volatile, but quite insipid. Spallanzani, the illustrious professor of natural history, in the university at Pavia, made a number of experiments upon this point, which are decisive in establishing the power of the gastric juice, while they show the falsity of the other theories. He enclosed, after the example of Reaumur, entire barley, in perforated metal tubes. These were given to common fowls, turkeys, &c. and after remaining, in some instances, forty-eight hours, were taken out of their stomachs undigested, and without being sensibly altered; but upon bruising the same food, and again introducing it by means of the tubes, when voided they were frequently found, in the course of the experiments, to be empty. The same able experimenter filled tubes with raw veal, finely divided, which were forcibly given to a hen. They remained in the stomach twenty-four hours, and when taken out the flesh was found to be considerably diminished; the parts which continued firm were red, and retained the true flavour of flesh.

If we deemed it necessary, a variety of other facts might be advanced, which prove that trituration assists, but is not positively requisite for digestion. In

fowls, possessed of muscular stomachs, it answers the purpose of mastication. In fact, it is to them what mastication is to man and to the phytivorous animals: they swallow their food whole, and the strong coats of the stomach break it down, and prepare it for solution in the gastric fluid. To estimate this force, we have only to consult the repeated experiments of Reaumur and Spallanzani. Tin tubes of considerable strength were found, after remaining some time in the stomach of turkeys, to be bent and distorted in a singular manner. ‘Having found,’ says Spallanzani, ‘that the tin tubes, which I used for common fowls, were incapable of resisting the stomach of turkeys, and not happening, at that time, to be provided with any tin plates of greater thickness, I tried to strengthen them, by foldering to the ends two circular plates of the same metal, perforated only with a few holes for the admission of the gastric fluid. But this contrivance was ineffectual; for, after the tubes had been twenty-four hours in the stomach of a turkey, the circular plates were driven in, and some of the tubes were broken, some compressed, and some distorted in the most irregular manner.’*

The same author employed, afterwards, a variety of sharp bodies, as angular pieces of glass, strong tin needles, and even lancets, fixed in balls of lead; and found them all to be equally incapable of withstanding the comminuting force of their stomach. ‘The ball,

* Spallanzani’s Dissertations, vol. i. p. 12.

‘armed with the lancets, was given to a turkey cock, and left eight hours in the stomach; at the expiration of which time, that organ was opened; but nothing appeared except the naked ball, the lancets having been broken to pieces.’* We observe, that children frequently swallow currants, cherries, &c. in an entire state, and void them as unbroken as when they were first taken into the stomach. These fruits, when ripe, are soft, easily broken, and incapable, we must suppose, of resisting the slightest degree of pressure.

Next in order, we proceed to examine the different kinds of fermentation, as promoting or impeding solution in the human stomach. The experiments already quoted from Reaumur and Spallanzani, although positive in proving that trituration is not necessary for digestion, do not shew but that fermentation is a part of the process. After Boerhaave, chymists have divided fermentation into three kinds: the spirituous, which furnishes ardent spirits; the acetous, which yields the acid of vinegar; and the putrefactive, which produces volatile alkaline gas, &c. For the first, or spirituous fermentation, saccharine bodies are absolutely, and when assisted by heat to a certain degree, with air and humidity, only necessary. The second, or acetous fermentation, depends on mucilage. The putrefactive, upon the presence of a gluten.

* Spallanzani's Dissertations, vol. i, p. 13.

Dr. Cullen, in his Lectures on the Materia Medica, delivered in the university of Edinburgh, in the year 1769, supposes, that the acetous fermentation always takes place during digestion, in the stomach of healthy persons; ‘And I am certain, from experiment,’ says he, ‘that the vegetable aliment first turns acid in the stomach; for every stomach, human or brute, is always, on examination, found to have an acid present in it. Hence that acescency is not a disease, but a step towards assimilation. Whenever the aliment enters into a high vinous fermentation, with copious generation of fixed air, commonly called gas silvestre, as of the same nature with that produced in the ordinary vinous process, it becomes a disease, and has the power of destroying the mobility and contractility of the moving fibres, and even the tone of the stomach itself.’

In order to produce fermentation, a considerable mass of matter favourable to it must be present; but this is by no means the case in the stomach of insects, birds, and other small animals, some of which we know have, in a surprising degree, the power of dissolving hard and even solid bodies. Secondly, if the stomach was a viscus intended merely as a vessel to contain the aliment for fermentation, as this doctrine, if established, would go to prove, why, I would ask, are tonics given, with such evident advantage, in debility of that organ? If this was the principal process, it would only be necessary to regulate it by mixing with our food a proportion of vegetables disposed for fermentation,

and every purpose would be answered, when indigestion occurred. The power of bitters, says the same writer, in correcting acidity and flatulence in the stomach, may be ascribed to their power of checking acedcent fermentation. He supposes, that digestion commences with a fermentation of the acedcent kind. If bitters check this, it must, agreeable to his own doctrine, impede, instead of assisting the process; for we cannot conceive that a substance, acting thus chymically, can produce two such opposite effects. A variety of tonics, among which are the different preparations of iron, have as salutary an effect in preventing acidity, by giving tone, we presume, to the stomach, as do the class of bitters.

Doctor Fordyce attentively examined the chyle, in the beginning of the duodenum of the sheep and the cow, with a view to ascertain whether, fermentation generally took place in the healthy, living subject. We might suppose that it would appear, if any where, in these animals, which live on acedcent, saccharine food; since every thing really necessary is present, and a mass considerably large and finely broken down. He did not however, discover, by the usual tests employed for detecting the presence of an acid, that any did really exist.

The supporters of the theory of fermentation, as being a necessary part of digestion, allege, against the experiments of Dr. Fordyce, and others who have experimented upon the chyle in the duodenum, that the bile is a real animal soap, composed of an alkali in suf-

ficient abundance to neutralize the acid produced by digestion, and prevent its being detected, after mixing with that fluid. A variety of correct and judicious experiments by Dr. Roebuck, of the Island of St. Croix, made with a view to analyze the bile, contradict and fully explode the theory of its saponaceous nature and Dr. Boerhaave's speculations, so ably supported by Cadet. These experiments show, that different neutral salts are generally present in the bile; as the muriate and phosphate of lime and soda; and that the bile of different animals, although somewhat various, does not contain a particle of an alkali in an uncombined state: therefore to neutralize the acid by an alkali or earth, it must decompose the muriate or phosphate of lime or soda (which is impossible from the natural order of affinity) contained in the bile and unite with their radicals producing an acetate of lime, or soda. But even if this chymical decomposition could take place, what would become of the acids originally combined in forming the neutral salts?

In order to determine whether an acid is always, or even frequently, present in the stomach, upon the establishing or contradiction of which the whole doctrine which we are examining depends, I had recourse to the following experiments.

EXPERIMENT I.

I gave to a middle aged man, of a delicate form, but enjoying a perfect state of health, a small quantity of emetic tartar in a glass of wine. He had breakfasted five hours before on tea, bread and butter and

faulage. In half an hour he was seized with nausea and vomiting. The first retchings threw up part of the food which had been eaten in the morning ; and after drinking plentifully of warm water, which I prevailed upon him to do, he vomited repeatedly, which emptied his stomach, perhaps entirely. Neither the first nor the last discharges altered the colour of litmus paper, nor the blue colour of the syrup of violets.

EXPERIMENT II.

For a considerable compensation I prevailed upon a healthy negro man, aged twenty-five years, to take a solution of emetic tartar at ten o'clock, A. M. He had breakfasted two hours before on coffee, and bread and butter. In a few minutes it produced a very considerable, long, and obstinate vomiting ; during which he threw up the whole of his breakfast, which was but little altered from its natural state, retaining its original smell and appearance. I could not, by the tests employed, discover the presence of acidity. This man was of a temperament opposite to that of the former ; being of a full habit, with a broad chest, and muscular form.

The extreme difficulty I found in procuring human subjects for experiments, prevented me from making so many of them as I could have wished, and at first intended ; and obliged me to have recourse to experiment made upon our domestic animals, whose similarity of structure and food will permit a fair analogy to be drawn.

EXPERIMENT III.

I fed a dog, for several days, on fresh boiled and baked meat, bread, cabbage and parsnips. During the time, he drank water when he chose, and occasionally had milk. In four hours after eating moderately, I had him killed, and after securing, by ligature, the upper and lower part of the duodenum, I opened the stomach and examined its contents. The beef, which had been eaten four hours before was dissolved in a considerable degree, the bread and cabbage a little, but not much altered. The whole mass was mild, of its natural odour, and without an appearance of putrefaction. After repeated immersions of the litmus paper in this, and in the chyle which I found in considerable quantity in the duodenum (owing probably to the animal's having been plentifully fed, while preparing for the experiment) I could not discover any change produced in its colour.

EXPERIMENT IV.

A cat having been fed moderately, for three days, on bread, fish, and roasted veal, during which time she drank nothing but milk, or a mixture of milk and water, was killed on the evening of the third day, after having fasted five hours. I found the contents of the stomach were perfectly digested, with the exception of a small piece of bread, which had been last eaten. I could not discover any acidity, or fœtor indicative of putrefaction.

EXPERIMENT V.

I fed a healthy male cat plentifully, for several days, on a diet of boiled beef, fish, bread, and potatoes; allowing him as much water as he pleased to drink. He was killed four hours after eating. On opening the stomach, I found the beef and fish soft, and considerably dissolved, retaining much of their natural flavour, sweet, and without rancidity or pungency. In this instance, the bread and potatoes had advanced much slower towards a state of chylication, than the other kinds of food which had been given a short time after, viz. the flesh and fish. Syrup of violets, and litmus paper, both of which tests I made use of, did not show the presence of any acidity.

EXPERIMENT VI.

While making the last experiment I procured a large dog of the mastiff breed, apparently healthy, but weak and much emaciated. He ate ravenously, every thing that was offered him, from whence I concluded that his leanness was owing to want of food alone. He was fed six days plentifully, on bread, beef, soup, and potatoes, at the end of which period eight hours after having eaten, he was killed; and, after having secured the lower part of the stomach, I opened its coats, and brought the digesting mass into view. I was surprized to observe a large number of the lumbrici, or round worms, some of which measured a foot, and many of them ten inches, in length. In other respects the digesting aliment looked natural, but had rather an un-

pleasant flavour, though not putrid. The general texture of the food, which had been eaten during the day, was destroyed, and much of it, in the lower part of the stomach, formed into chyle, and ready to pass into the duodenum. After repeated trials, my tests could not discover an appearance of acidity, either in the stomach or in the duodenum, which I also examined with attention.

From the result of these experiments, conducted with much care and attention, we infer, that when the stomach is in a state of health, the appetite good, and proper food only employed, digestion goes on rapidly, without the aliment undergoing any fermentation by which an acid is produced, either in the course of the stomach or duodenum: and farther, that when acidity does take place, it is a proof of the unhealthy condition of the stomach. The stomach may, no doubt, have its functions impeded, like every other part of the system, by too much or too little excitement. In the diseased state of the stomach, called dyspepsia, we suppose, that the action of the vessels pouring out the gastric liquor for the purpose of digestion, is sometimes excessive. From this view of the subject, and from the small, frequently chorded pulse, so often observed in dyspeptic habits, might we not reasonably expect greater success from depletion than from stimulants and tonics,—the remedies heretofore most generally employed, owing to the idea, that dyspepsia depends on imbecility, and want of tone in the muscular fibres of the stomach?

In preparing my animals, I was attentive to give them such food only, as they would eat with avidity; principally flesh, but with a sufficient proportion of vegetables to undergo the vinous, or acetous fermentations if either was necessary for the complete chylification of our food.

On a review of the above experiments, we find, that animal food was more readily soluble in the stomach of dogs and cats, than bread, potatoes, or parsnips. I was more particular in observing this fact, because the experiments of Walæus, made upon dogs, had led me to believe, that even some carnivorous animals digested herbs, and bread sooner than butcher's meat.* The constant state of rest in which the animals were kept for several days, previous to being killed, was favourable to the formation of an acid, by assisting fermentation.

The arguments in favour of the theory of animal putrefaction, which we are next to consider, as occurring during, and constituting a part of the process of digestion, requires I conceive, but little labour to refute. During animal putrefaction, the subject matter, after losing its natural smell, gives out a putrid, nauseous odour, with one of a more penetrating kind, arising from the disengagement of ammoniacal gas, the smallest quantity of which from its extreme volatility, would be made, in the most disagreeable manner, sensible to our feelings during digestion.

* Vid. Epist. de mot. chyl. et sang. ad Thom. Bartholin.

Dr. Stevens, in an inaugural thesis published at Edinburgh, in the year 1777, tells us that he collected, from a dog, a quantity of fresh gastric juice, half an ounce of which he added to twelve grains of beef, which had been previously put into a vial. He put the same quantity of beef into another vial, and poured upon it half an ounce of water. Having placed both in a furnace heated to 102 or 103 degrees of Fahrenheit's thermometer, and suffering it to remain in that temperature for eight hours, he examined the vials, and found that the beef which was immersed in the gastric fluid was entirely dissolved, while the other had undergone no sensible alteration. Twenty-four hours afterwards the two vials were removed from the furnace, and attentively examined. The one which contained the gastric juice and beef, emitted a rancid, and pungent smell; while the other, with the water and beef, had become putrid, and emitted an intolerable stench. During the solution of the beef in the gastric juice, there were no signs of fermentation in the vial, such as an appearance of air, &c.* A repetition of the experiment produced a similar result. Spallanzani's experiments, made on the gastric fluid of various animals, had the same effect with those made by Dr. Stevens. Some of them, indeed, go farther and shew that animal food may even be recovered from a slight degree of putrescency, by being placed for a short time in gastric juice.†

* Stevens's Dissertation, Exp. 23.

† Spallanzani's Dissertations, vol. i. p. 349, 353, 355.

Dr. Cullen, whose ingenuity and abilities we must ever venerate, although we cannot always admit his speculations, positively says, that no man can subsist, even for a few days, on animal food alone, without its becoming highly putrescent in the stomach and producing nausea and thirst; and, when carried into the bowels, violent purging, cholera, and dysentery, from putrid exhalations. This disposition of the animal food to undergo putridity, he supposes, is corrected by the quantity of vegetable matter, which we are in the habit of mixing with it at our meals.

We are informed by the most respectable authorities, that whole nations subsist on animal food alone, without experiencing the diseases which the professor tells us would be produced in a few days by such a diet. Dr. Fordyce, in his treatise upon digestion, observes, that the Laplander, inhabiting a country extremely cold and incapable of affording vegetables for the subsistence of its inhabitants, lives for the greater part of the year upon the flesh of the reindeer, without mixing with it any vegetable food; and no appearance is indicated of a putrescent matter being formed in the stomach, or organs of digestion. The inhabitants of the banks of the Orange river, in Africa, says the same author, live on limpets, dead and putrid seals, and whales, without tasting a particle of vegetable food of any kind whatever, except aromatics.

If a high degree, or indeed, any putrefaction took place during digestion, the whole of the circulating fluids must, in a short space of time, become affected through the medium of the absorbent system; the breath, and the secretions necessary to life, would become acrimonious, and the evil, constantly increasing by the taking in of fresh food, would end only with the extermination of the people using it, unless a different diet was resorted to.

It is a fact well known to those who are acquainted with the aborigines of our country, that the tribes, particularly those which inhabit the northern parts of the United States, frequently subsist, for whole weeks, on animal food alone, when hunting at a distance from their towns, or at war. In the latter case, they eat what the people of the back country call *jirk*, which is the muscular part of the game which they kill, preserved by drying and smoaking over a very gentle fire, so as to deprive it entirely of its juices. When thus prepared, it will keep for a long time during the heat of summer, and is very nutritious for its weight and bulk; a circumstance of great importance to Indians on long excursions. The savage will live, exposed to the greatest fatigue, on a few ounces of this substance, which nothing but the power of habit could enable him to do.

Not only man, who by nature is restricted to no particular kinds of aliment, can subsist on one entirely of flesh, but even phytivorous animals, intended cer-

tainly to live upon herbage, grain, &c. In proof of which Dr. Barton informed me of the following interesting fact: During a voyage of two and thirty days across the Atlantic, said the professor, a pair of (*sciurus volucella*, or) flying squirrels, were fed on dry salted beef, which they continued to eat until the vessel arrived in Europe: in this time they became fond of their animal diet, and refused, afterwards, their accustomed vegetable one. A similar one, I think, is mentioned by Reaumur, but not having, at this time, an opportunity of consulting his works, I will not insist that the fact is recorded by him. A sheep was fed, for a considerable length of time, on flesh, varying in kind, and differently prepared. He became, at length, fond of it, and when the two were offered, ate it in preference to the vegetable.

In the course of the experiments on ruminating animals, as the sheep and the ox instituted by Dr. Stevens, he discovered that the gastric juice readily dissolved vegetables, and made but little impression upon beef, mutton, and veal. My experiments upon dogs and cats, carnivorous animals, show that they digest animal food much sooner than vegetable, but still, that they are capable of completely digesting the latter. Though they are altogether carnivorous, necessity, by obliging them to eat frequently of vegetables, makes it, at length, a customary part of their food. Had the animals employed by Dr. Stevens been gradually deprived of the use of vegetables, and fed upon flesh, they would in a short time, no doubt, have digested the latter with perfect facility.

From these several experiments, we conclude that nature has given to the different classes of animals solvents of different qualities and powers, calculated for the solution of the peculiar food, which she intended them to use; but at the same time, capable of being changed, if requisite for the life of the individual, and accommodated for the solution of food of a different nature.

Independent of the arguments which we have advanced the variety of facts mentioned, particularly applicable to the point in question, can admit of no refutation: they are, we conceive, sufficient to establish the position, that putrefaction is a process never, perhaps, present during the solution of our food in the stomach, as fermentation frequently is, owing to an unhealthy secretion of the gastric liquor, when that fluid from insufficiency in point of quantity, or quality, is incapable of resisting the disposition of the vegetable part of our food to run into fermentation. To admit either of the doctrines which we have been endeavouring to refute, would be considering nature as deviating from that general order of simplicity which marks her productions, throughout the whole of the animated world; for neither of the three kinds of fermentation alone can account for the various phenomena produced in digestion. If the acetous fermentation takes place as a necessary part of it, we must believe that the putrid does likewise; or how shall we account for the solution of animal substances? For in no circumstances do they undergo the acetous fermentation. The experiments

of Stevens, with the vials, enclosing beef in the gastric juice, and my own with the dogs and cats, disprove the theory of putridity. Lastly, the acetous fermentation cannot in any degree take place without evolving an acid, which our experiments could not, in a single instance, discover.

Dr. Stevens performed a number of experiments upon a poor German who for many years had gained a miserable subsistence by swallowing stones for the amusement of spectators ; he gave him to swallow silver spheres, perforated, so as to admit the gastric fluid freely to pass : at different times were enclosed fish, raw and boiled beef, pork, and cheese ; the sphere was, for the most part, retained from thirty to forty hours, and when voided, generally found to have lost the most, and frequently the whole of its contents. Having observed that animal substances were readily dissolved by the gastric juice, the Doctor tried whether the same effect would be produced on vegetables.—He enclosed in his sphere raw parsnip and potatoe, which were swallowed as before by the German, and retained for forty-eight hours ; and when voided, not a vestige of either remained. Apples and turnips, both raw and boiled, were digested in thirty-six hours.

The same experimenter enclosed live leeches and earth worms in different spheres, which the German, as usual, swallowed. He retained them for some time, and when discharged in the natural way, the animals were deprived of life, and completely dissolved. It is a

pleasing reflection, that no reptile, if taken into the stomach accidentally, or otherwise, can resist the operation of this powerful secreted menstuum, the gastric liquor. Worms, hatched in the intestines, are alone an exception.

In accounting for the process of digestion by solution alone, a very natural question has frequently been asked by its opposers: ‘If the gastric liquor acts as a solvent, why is not the stomach acted upon, seeing it is composed of the same materials we make use of in diet?’ The stomach, as long as it retains the principle of life, is not affected by the gastric liquor; but the moment that this principle is destroyed, and death takes place, it is equally liable to be corroded as other substances. The same thing happens to live animals generated in the alimentary canal. As long as they have the vital principle, it resists the power of digestion. ‘Hence it is,’ Mr. Hunter remarks, ‘that we find animals of various kinds living in the stomach, or even hatched and bred there; but the moment that any of these lose the living principle, they become subject to the digestive powers of the stomach. If it were possible, for example, for a man’s hand to be introduced into the stomach of a living animal, and kept there for some considerable time, it would be found that the dissolvent powers of the stomach could have no effect upon it. But, if the same hand were separated from the body, and introduced into the same stomach, we should then see, that the stomach would immediately act upon it. Indeed, if this were not the

‘case, we should find that the stomach itself ought to
 ‘have been made of indigestible materials; for, if the
 ‘living principle was not capable of preserving animal
 ‘substances from undergoing that process, the stomach
 ‘itself would be digested. But we find, on the con-
 ‘trary, that the stomach, which at one instant, that is,
 ‘while possessed of the living principle, was capable of
 ‘resisting the digestive powers which it contained; the
 ‘next moment, viz. when deprived of the living prin-
 ‘ciple, is itself capable of being digested; either by the
 ‘digestive power of other stomachs, or by the remains
 ‘of that power which it had of digesting other things.’

Mr. Hunter mentions three cases of persons who
 had died of violent deaths, without previous indispo-
 sition, where he observed the stomach had been cor-
 roded by the gastric fluid. ‘In these cases,’ says he,
 ‘the contents of the stomach are generally found loose
 ‘in the cavity of the abdomen, about the spleen and
 ‘diaphragm. In many subjects this digestive power
 ‘extends much farther than through the stomach.—
 ‘I have often found, that, after it had dissolved the
 ‘stomach at the usual place, the contents of the sto-
 ‘mach had come into contact with the spleen and
 ‘diaphragm, had partly dissolved the adjacent side of
 ‘the spleen, and had dissolved the stomach quite
 ‘through; so that the contents of the stomach were
 ‘found in the cavity of the thorax, and had even affect-
 ‘ed the lungs in a small degree.’

It is only by the aid of facts and experiments that we can arrive at truth, particularly in researches connected with natural philosophy and medicine. The physiologist who would instruct himself, or teach others, by conjecture alone, had better do nothing, but leave the subject for others, possessed of more industry or more leisure than himself.

FINIS.



